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ROOT ABSORPTION FROM SOLUTIONS AT MINIMUM CONCENTRATIONS

R. B. Harvey and R. H. True

In former papers by R. H. True and H. H. Bartlett (1, 2) there was found to be a point in the absorption curve for the lupine grown in various salt solutions, at which the absorption and excretion of electrolytes were in equilibrium. For the lupine this value was found to be about 16×10^{-6} normal expressed as NaCl. The conditions which exist at this point have been further studied in the squash, peanut, and soy bean. The values have been found to differ slightly for the various plants used.

The absorption minimum for the same plant seems to have nearly the same value independent of the volume of the solution, the concentration of the salt, or the kind of nutrient salt used. The quantity of salt solution offered must, of course, be within the requirements of the plant during its growth period, so that the minimum may be reached, and the concentration must be below the toxic limit. The constancy of the equilibrium concentration when once attained is shown by the graph for sweet corn in calcium nitrate (fig. 1). The value of $12–15n \times 10^{-6}$ $Ca(NO_3)_2$ was held for 24 days by five cultures in this series. In cultures of this plant grown in KNO_3 and Mg $(NO_3)_2$, practically the same value was obtained. The graph for the absorption of the squash in $Ca(NO_3)_2$ (fig. 2) gives the average values for twelve cultures at each concentration indicated. The squash seems unable to maintain a concentration as low as corn, giving a value of $35–40n \times 10^{-6}$ $Ca(NO_3)_2$ as its absorption minimum. The peanut is able to maintain a concentration of $50n \times 10^{-6}$; the soy bean one of about $20n \times 10^{-6}$ expressed as $Ca(NO_3)_2$. Sweet corn gave a more nearly constant value than the other plants tested.

The specific minimum concentration for absorption is controlled by at least two classes of factors. One external factor, the concentration of CO_2 in the air and in the solution saturated with it at the given temperature, like other similar purely external factors, must be the same for different plants growing under the same conditions.

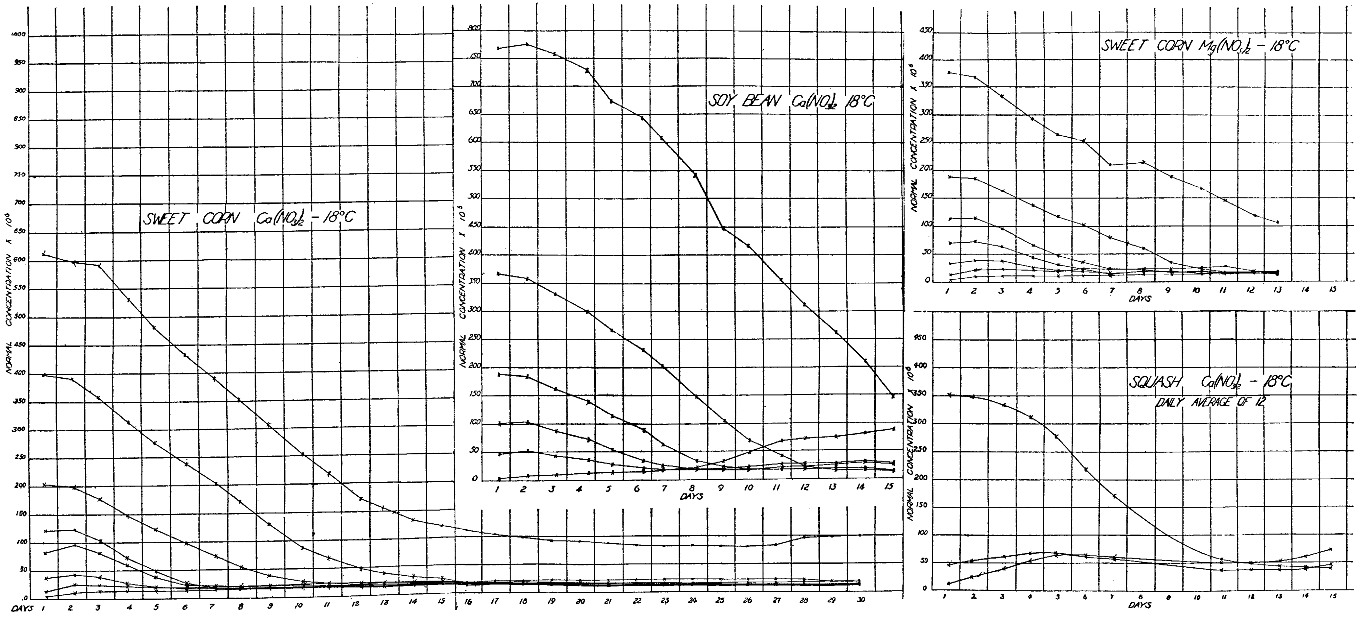

FIG. 1. Graph showing rates of root absorption from solutions of $Ca(NO_3)_2$ and $Mg(NO_3)_2$.

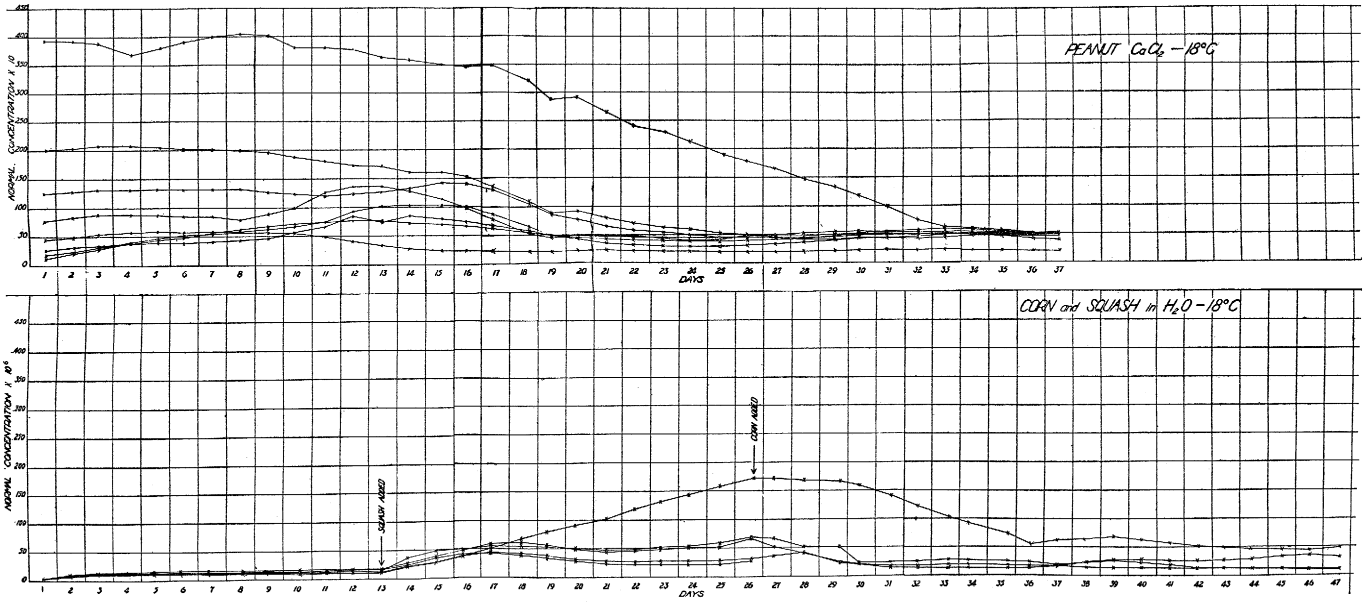

FIG. 2. Graph showing rates of root absorption from water and from solutions of $CaCl_2$.

Another class of factors depends upon the plant for their values. Such would be the chemical character of the cell wall and the deeper lying cell membranes and other structures. These membranes contain dissociating substances, such as calcium pectate and many other substances (3). The value of the minimum concentration for absorption must be determined by the balance of ion interchange between the membrane surface and the solution. It would seem likely that when the syntheses within the cell which tend actively to withdraw ions toward the interior is balanced by the tendency toward dissociation and loss of ions at the bounding membrane, the condition here seen would be realized.

Since both of the internal factors here mentioned depend on structure and function supposed to be specific, it is hardly surprising that this minimum concentration should also be specific. To test this point corn was grown in conductivity water for 10 days after equilibrium had been established. For six cultures of five plants each the variation during this period was $10–18n \times 10^{-6}$ expressed as KCl. At the end of that time the solution in one beaker was boiled to remove CO_2, made up to its original weight with recently distilled conductivity water, stoppered to prevent the absorption of CO_2, and read at 18° C. The total concentration before boiling was $11 \times 10^{-6}n$ as KCl. The CO_2 concentration was $6 \times 10^{-6}n$ as KCl, leaving a residual concentration of $5 \times 10^{-6}n$ of non-volatile electrolytes which the corn is unable to absorb. Squashes were then placed in the set-up. That the solution was not in equilibrium with the squash was shown by the rise in concentration, much as is seen in distilled water. After a period of leach and subsequent absorption, equilibrium was established at a concentration higher than the value for corn. Infection occurred in one culture, a fact which became apparent in the continual leach of electrolytes. The beaker having the lowest value was tested as before. The concentration before boiling was 28.7, after boiling $22.3n \times 10^{-6}$ KCl, leaving a residual concentration of $6.4n \times 10^{-6}$ expressed as KCl, which is due to volatile electrolytes. The close agreement with the former value for CO_2 is apparent as well as the higher average value for the equilibrium concentration maintained by the squash. The squash was again replaced by corn and the concentration sank to its former value for corn in all cultures except the one which became infected.

In a recent article Stiles (4) says: "It is quite conceivable that below a certain point, concentrations of the nutrient solution might be so low that the root could not absorb enough salts from the solution simply because of the dilution of the latter." This surmise seems entirely correct in view of the data here presented.

To maintain so low a value for the ion content of the solution about it for three weeks, as is here seen in sweet corn, either the cell membrane must possess almost perfect directional semipermeability and be able to hold the electrolytes during life, or the ions present must be chemically combined into compounds which are but little dissociated. The variation in the deviation from the value for CO_2 saturation indicates specific differences in the rate of ion production. Since upon the death of the plant leaching occurs, the assumed directional permeability is to be ascribed to some living membrane of the plant, or the leach is due to the breaking down of ion compounds of the cell substances upon the death of the protoplasm.

SUMMARY

The equilibrium concentration of electrolytes established by the squash, peanut, soy bean, and sweet corn grown in water culture was found to be specific for each plant.

The equilibrium concentration value is independent of the kind of nutrient salt used, the concentration of the electrolyte, or the volume of the solution; provided, that the concentration is below the toxic limit for the plant, and that the quantity of the salt is within the requirement of the plant during the period of growth.

At the point of equilibrium between the plant and the solution, the electrolyte content of the solution is determined, first, by certain factors which are constant for different plants under the same conditions, such as the CO_2 equilibrium with the air; and, second, it is determined by the rate of cleavage of ion-producing compounds of the cell and the reabsorption of the ions produced.

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LITERATURE CITED

1. **True, R. H., and Bartlett, H. H.** Absorption and excretion of salts by roots as influenced by concentration and composition of culture solutions. I. Concentration relations of dilute solutions of calcium and magnesium nitrates to pea roots. U. S. Dept. Agri. Bur. Pl. Ind. Bull. 231. 1912.
2. **True, R. H.,** and **Bartlett, H. H.** The exchange of ions between the roots of *Lupinus albus* and culture solutions containing one nutrient salt. Amer. Journ. Bot. **2**: 256, 264, etc. 1915.
3. **Roberts, E. A.** The epidermal cells of roots. Bot. Gaz. **62**: 488–506. 1916.
4. **Stiles, W.** On the interpretation of the results of water culture experiments. Annals of Botany, **30**: 427. 1916.